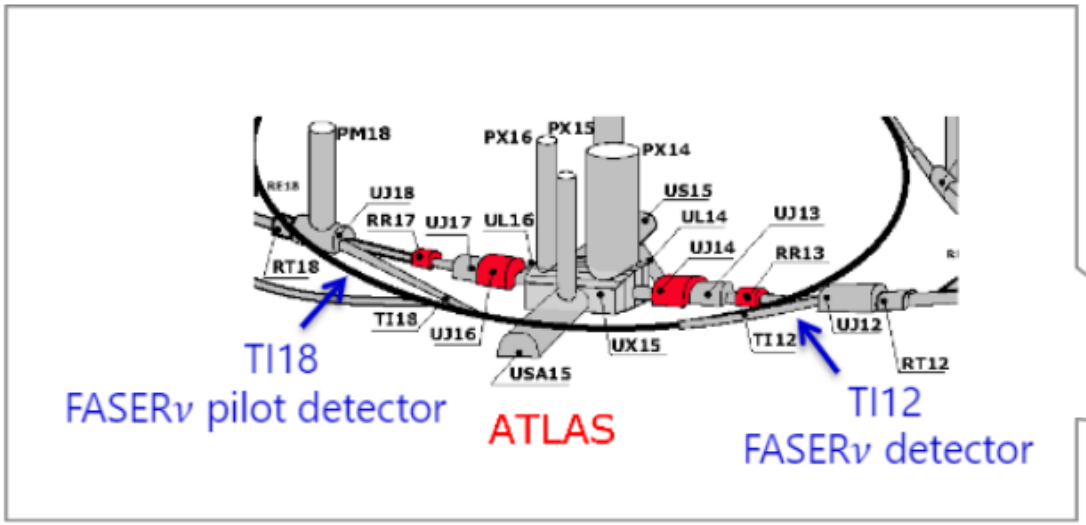
Pion structure

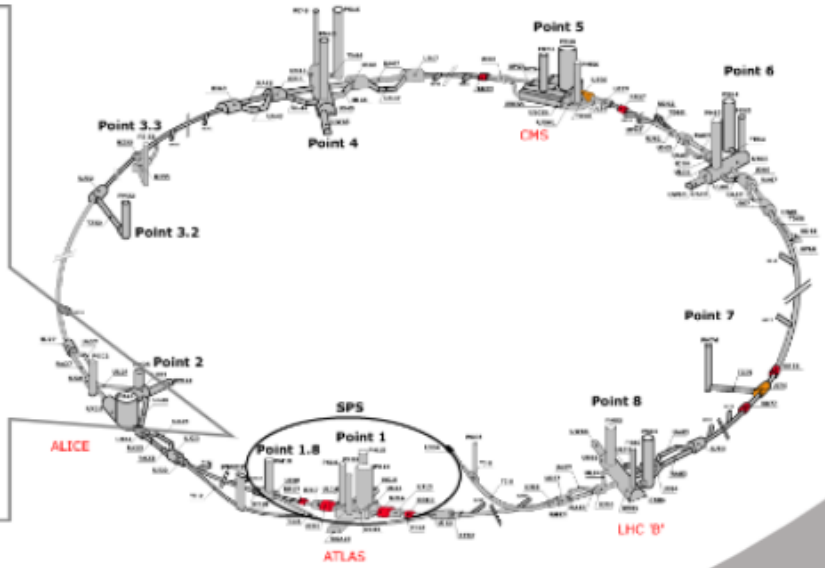
momentum distribution

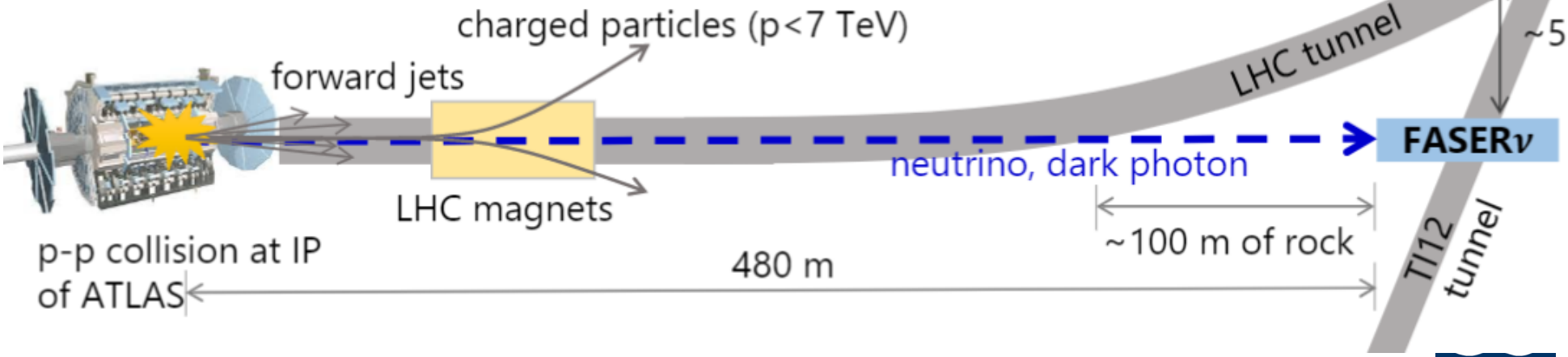
Hamed Abdolmaleki

(On Behalf xFitter developer team)

FASERν







From FPF whitpaper

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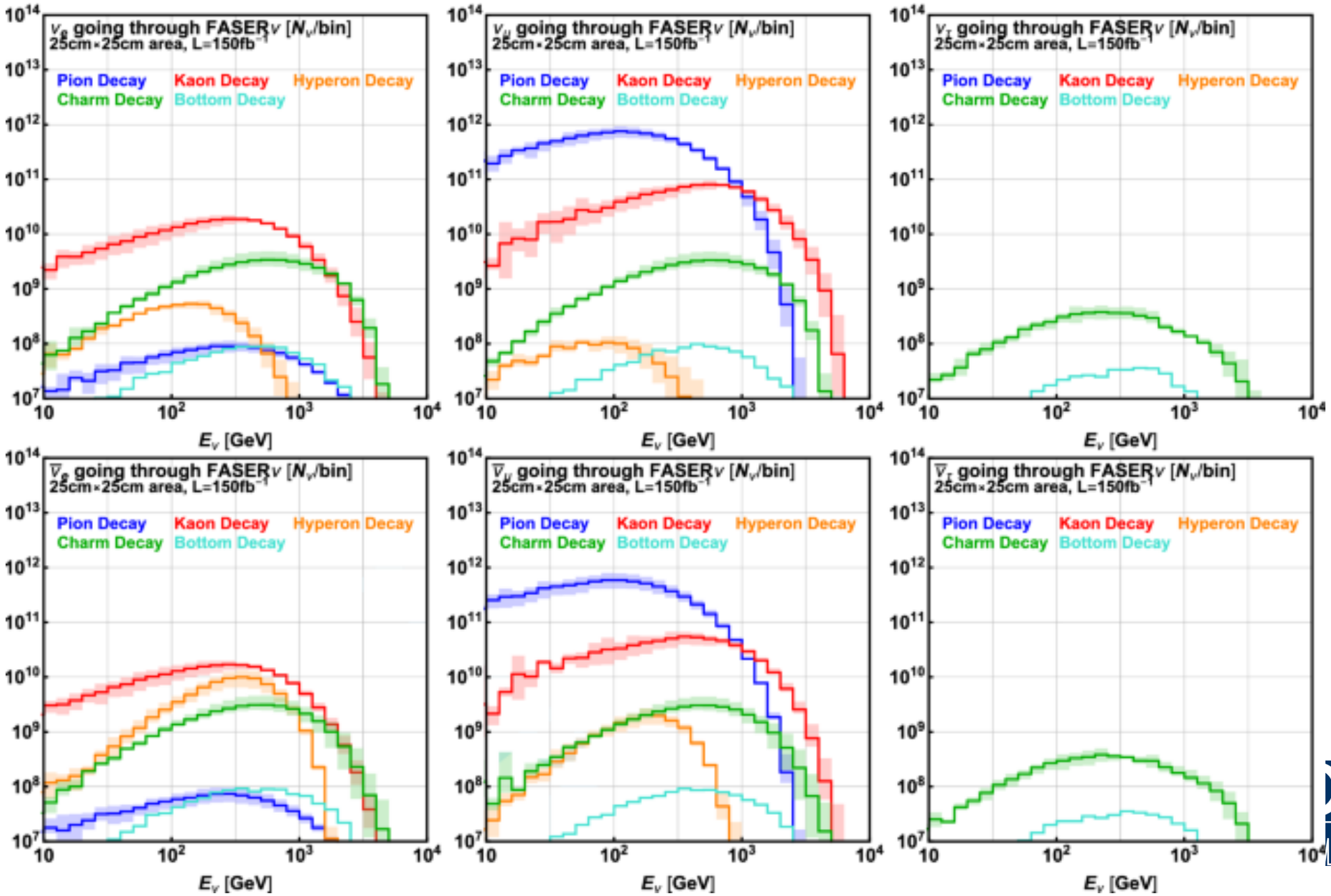
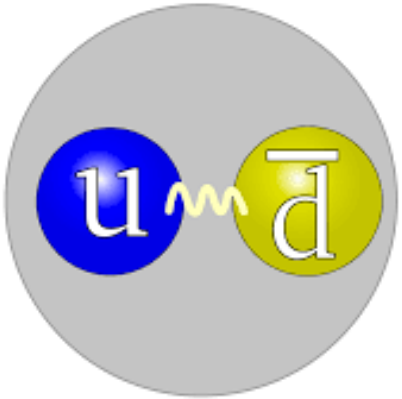


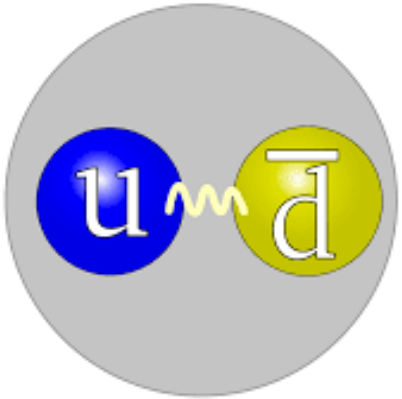
Pion Structure



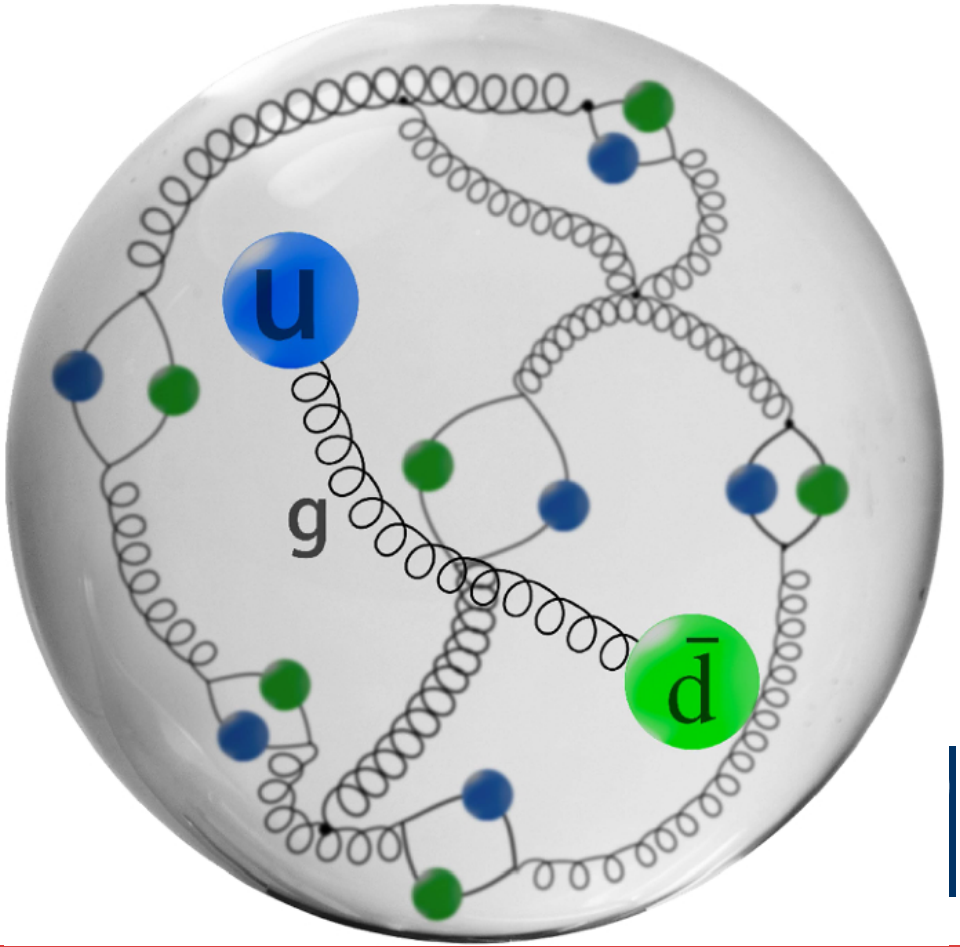
Simple model of Pion structure

Theoretically, the pion is a simpler system than the proton.Consequently, the pion structure has been investigated in several nonperturbative theoretical models.

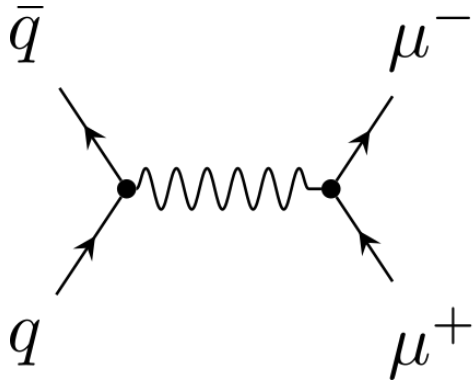
Pion Structure

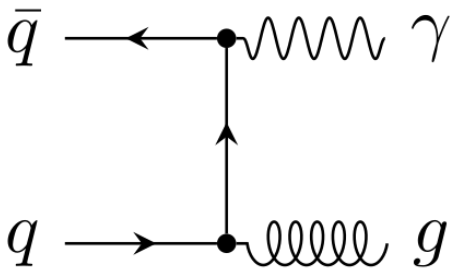


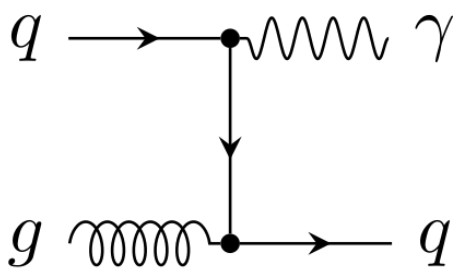
Experimentally, Pion structure is more complicated,so the pion PDF is known mostly from QCD analyses of Drell-Yan (DY) and prompt photon production data.



Pion Structure

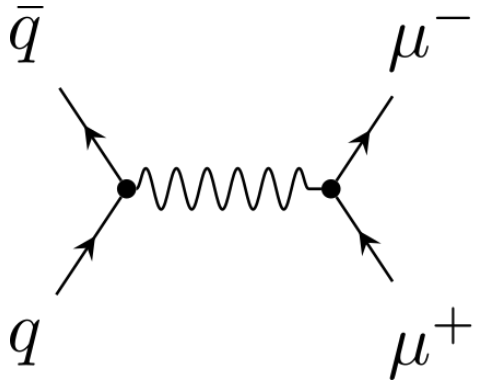


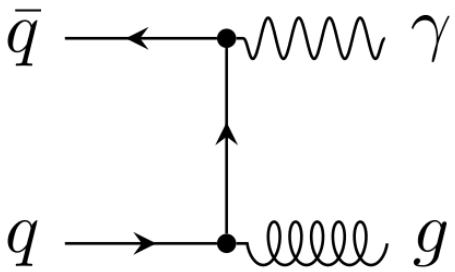


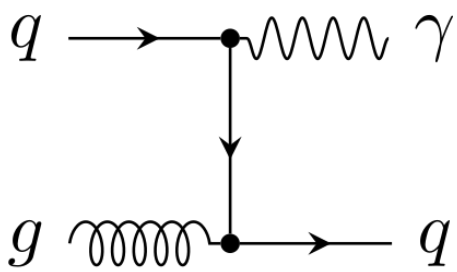


Dinamically, Within a dynamical approach, only the relatively well-known valence distribution is determined from DY data, with the sea and gluon content at a very low initial scale fixed by simplifying assumptions

Pion Structure

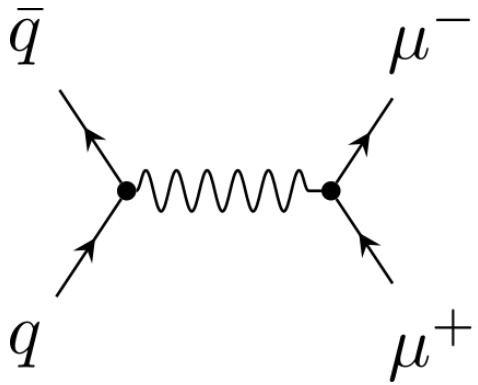


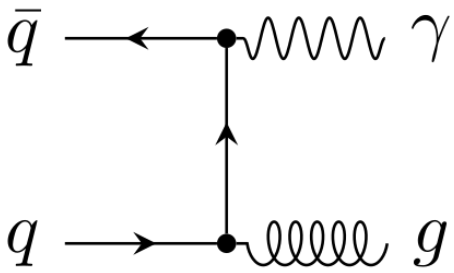


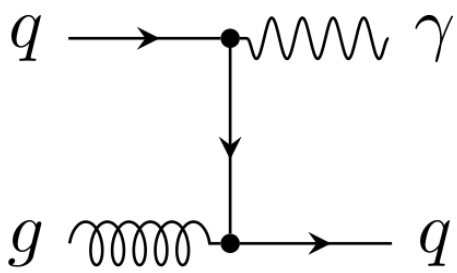


Prompt photon (WA70) data provide constraints on both the quarks and gluons in our kinematic range

Pion Structure







This analysis is based on Drell-Yan data from NA10 and E615 experiments, and on photon production data from the WA70 experiment.

Pion Structure

Parameterization form: the π^- PDF, $xf(x, Q^2)$ parameterize at initial scale $Q_0^2 = 1.9\ GeV^2$

$$
\begin{aligned}
xv(x) &= A_v x^{B_v}(1-x)^{C_v}(1+D_v x^{\alpha}),\\
xS(x) &= A_S x^{B_S}(1-x)^{C_S}/\mathcal{B}(B_S+1, C_S+1),\\
xg(x) &= A_g(C_g+1)(1-x)^{C_g},
\end{aligned}
$$

Neglecting electroweak corrections and quark masses, charge symmetry is assumed: $d = \bar{u}$, and SU(3)-symmetric sea: $u = \bar{d} = s = \bar{s}$.

$$
\begin{aligned}
v &= d_v - u_v = (d - \bar{d}) - (u - \bar{u}) = 2(d-u) = 2d_v,\\
S &= 2u + 2\bar{d} + s + \bar{s} = 6u,\\
g &= g,
\end{aligned}
$$

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$$

Quark-counting and momentum sum rules:

	D_v=0	free D_v
$\chi^2/N_{\rm DoF}$	444/373=1.19	437/372=1.18
A_v	2.60	1.72
$\langle xv \rangle$	0.56	0.54
B_v	0.75 ± 0.03	0.63 ± 0.06
C_v	0.95 ± 0.03	0.26 ± 0.13
D_v	0	-0.93 ± 0.06
$A_S = \langle xS \rangle$	0.21 ± 0.08	0.25 ± 0.09
B_S	0.5 ± 0.8	0.3 ± 0.7
C_S	8 ± 3	6 ± 3
$A_g = \langle xg \rangle$	0.23	0.20
C_g	3 ± 1	3 ± 1

$< xf >= \int_0^1 xf(x)dx$

Minimazing:

$$\chi^2 = \sum_i \frac{(d_i - \tilde{t}_i)^2}{\left(\delta_i^{\text{syst}}\right)^2 + \left(\sqrt{\frac{\tilde{t}_i}{d_i}}\,\delta_i^{\text{stat}}\right)^2} + \sum_\alpha b_\alpha^2,$$

Experiment	Normalization uncertainty	Normalization factor	χ^2/N_{points}
E615	15 %	1.160 ± 0.020	206/140
NA10 (194 GeV)	6.4%	0.997 ± 0.014	107/67
NA10 (286 GeV)	6.4%	0.927 ± 0.013	95/73
WA70	32%	0.737 ± 0.012	64/99

	$\langle xv \rangle$	$\langle xS \rangle$	$\langle xg \rangle$	Q^2 (GeV^2)
JAM [31]	0.54 ± 0.01	0.16 ± 0.02	0.30 ± 0.02	1.69
JAM (DY)	0.60 ± 0.01	0.30 ± 0.05	0.10 ± 0.05	1.69
this work	0.55 ± 0.06	0.26 ± 0.15	0.19 ± 0.16	1.69
Lattice-3 [18]	0.428 ± 0.030			4
SMRS [25]	0.47			4
Han et al. [44]	0.51 ± 0.03			4
GRVPI1 [27]	0.39	0.11	0.51	4
Ding et al. [11]	0.48 ± 0.03	0.11 ± 0.02	0.41 ± 0.02	4
this work	0.50 ± 0.05	0.25 ± 0.13	0.25 ± 0.13	4
JAM	0.48 ± 0.01	0.17 ± 0.01	0.35 ± 0.02	5
this work	0.49 ± 0.05	0.25 ± 0.12	0.26 ± 0.13	5
Lattice-1 [16]	0.558 ± 0.166			5.76
Lattice-2 [17]	0.48 ± 0.04			5.76
this work	0.48 ± 0.05	0.25 ± 0.12	0.27 ± 0.13	5.76
WRH [26]	0.434 ± 0.022			27
ChQM-1 [13]	0.428			27
ChQM-2 [15]	0.46			27
this work	0.42 ± 0.04	0.25 ± 0.10	0.32 ± 0.10	27
SMRS [25]	0.49 ± 0.02			49
this work	0.41 ± 0.04	0.25 ± 0.09	0.34 ± 0.09	49

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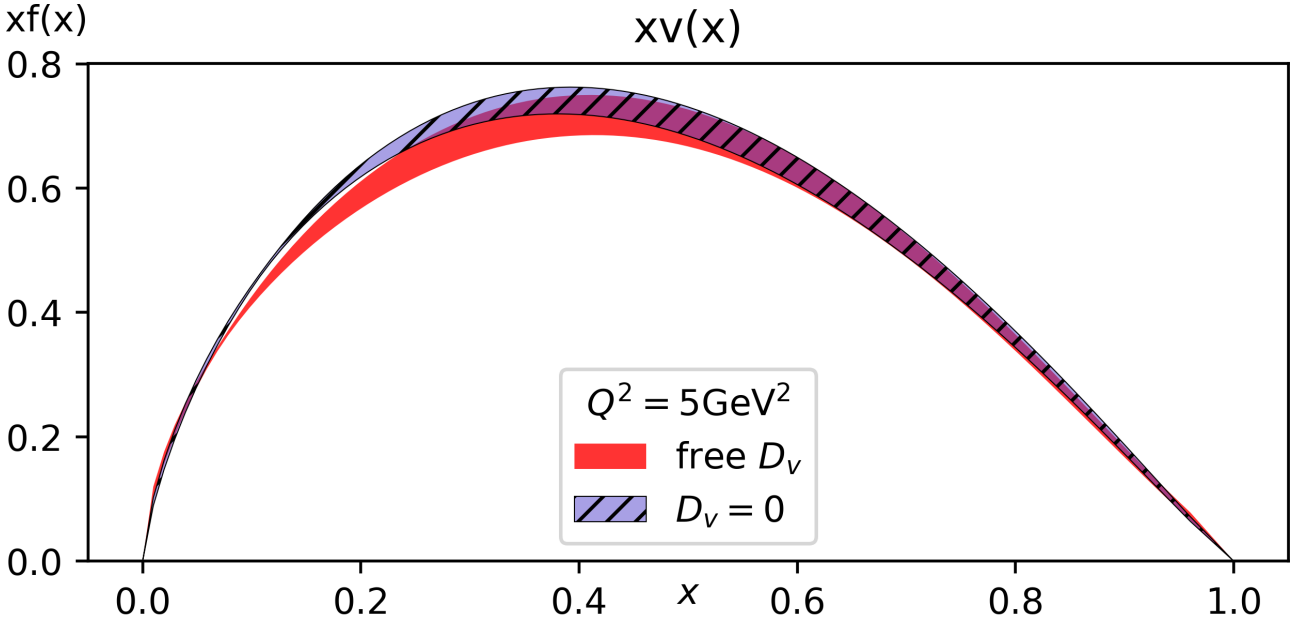
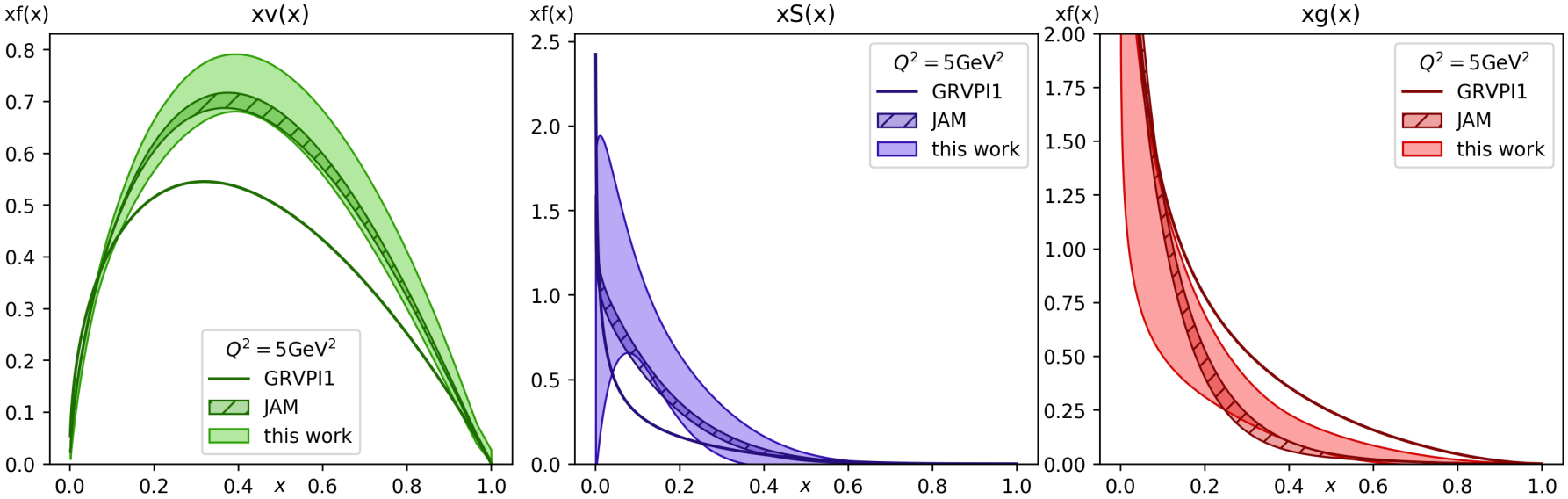
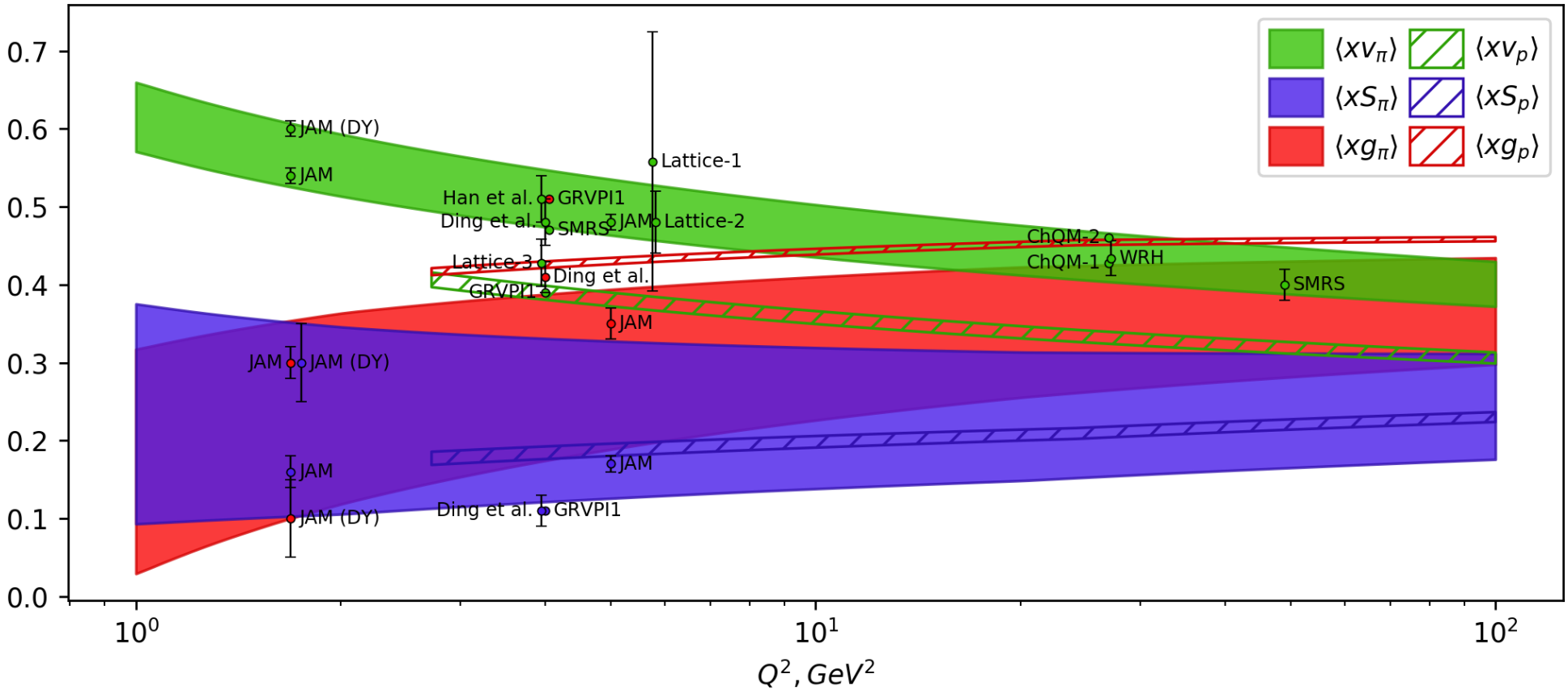
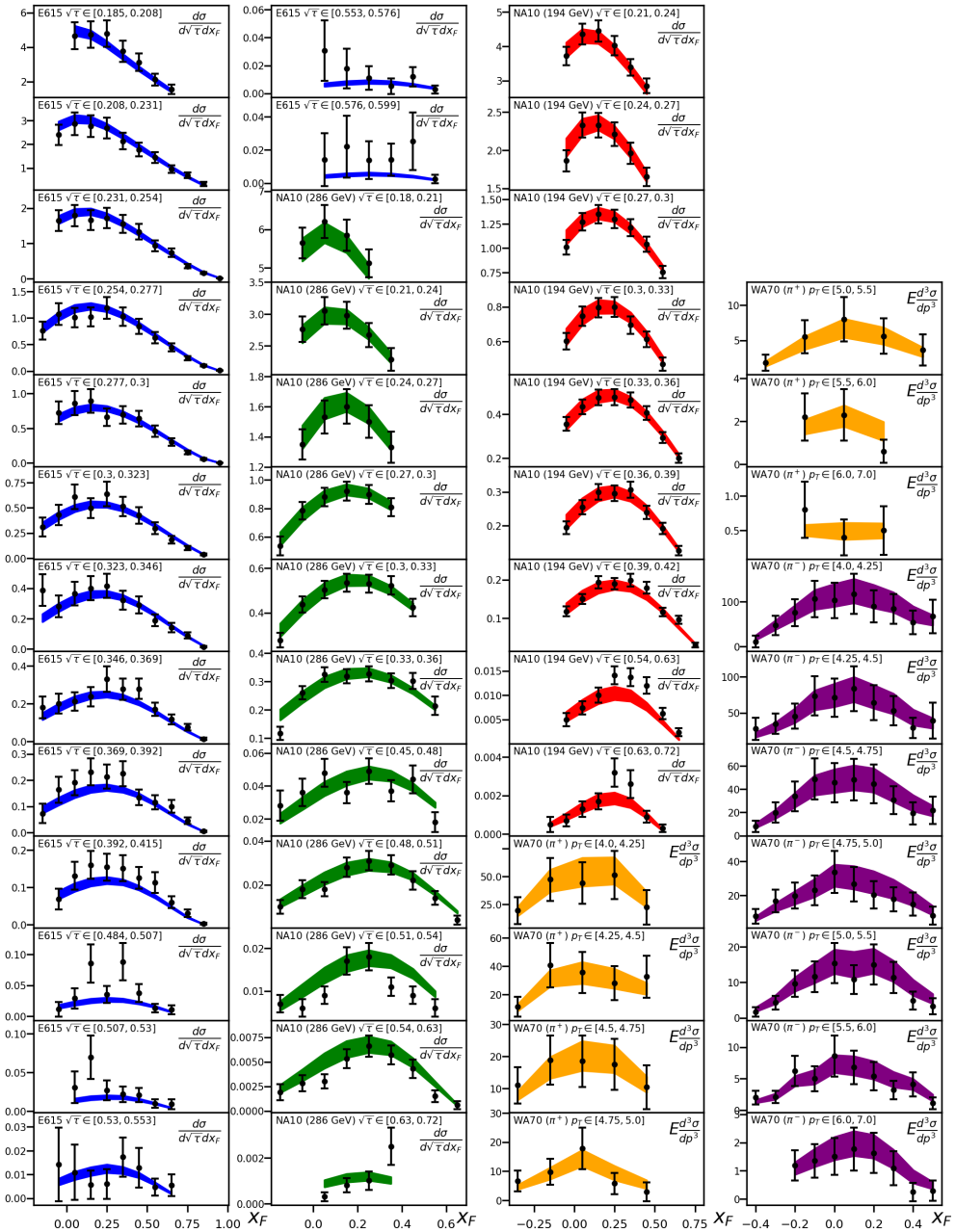


Valence distrubution extracted by minimal parameterization: $D_v = 0$



Compared pion PDF with the modern pion PDFs


$\langle xv_\pi \rangle$
$\langle xv_p \rangle$
$\langle xS_\pi \rangle$
$\langle xS_p \rangle$
$\langle xg_\pi \rangle$
$\langle xg_p \rangle$
JAM (DY)
JAM
Han et al.
GRVPI1
Ding et al.
SMRS
Lattice-1
JAM
Lattice-2
Lattice-3
Ding et al.
GRVPI1
ChQM-2
ChQM-1
WRH
SMRS
JAM
JAM
JAM (DY)
JAM
JAM (DY)
JAM
Ding et al.
GRVPI1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
10^0
10^1
10^2
Q^2, GeV^2


E615 $\sqrt{\tau} \in [0.185, 0.208]$
E615 $\sqrt{\tau} \in [0.208, 0.231]$
E615 $\sqrt{\tau} \in [0.231, 0.254]$
E615 $\sqrt{\tau} \in [0.254, 0.277]$
E615 $\sqrt{\tau} \in [0.277, 0.3]$
E615 $\sqrt{\tau} \in [0.3, 0.323]$
E615 $\sqrt{\tau} \in [0.323, 0.346]$
E615 $\sqrt{\tau} \in [0.346, 0.369]$
E615 $\sqrt{\tau} \in [0.369, 0.392]$
E615 $\sqrt{\tau} \in [0.392, 0.415]$
E615 $\sqrt{\tau} \in [0.484, 0.507]$
E615 $\sqrt{\tau} \in [0.507, 0.53]$
E615 $\sqrt{\tau} \in [0.53, 0.553]$
E615 $\sqrt{\tau} \in [0.553, 0.576]$
E615 $\sqrt{\tau} \in [0.576, 0.599]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.18, 0.21]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.21, 0.24]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.24, 0.27]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.27, 0.3]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.3, 0.33]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.33, 0.36]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.45, 0.48]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.48, 0.51]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.51, 0.54]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.54, 0.63]$
NA10 (286 GeV) $\sqrt{\tau} \in [0.63, 0.72]$
NA10 (194 GeV) $\sqrt{\tau} \in [0.21, 0.24]$
NA10 (194 GeV) $\sqrt{\tau} \in [0.24, 0.27]$
NA10 (194 GeV) $\sqrt{\tau} \in [0.27, 0.3]$
NA10 (194 GeV) $\sqrt{\tau} \in [0.3, 0.33]$
NA10 (194 GeV) $\sqrt{\tau} \in [0.33, 0.36]$
NA10 (194 GeV) $\sqrt{\tau} \in [0.36, 0.39]$
NA10 (194 GeV) $\sqrt{\tau} \in [0.39, 0.42]$
NA10 (194 GeV) $\sqrt{\tau} \in [0.54, 0.63]$
NA10 (194 GeV) $\sqrt{\tau} \in [0.63, 0.72]$
WA70 (π^+) $p_T \in [4.0, 4.25]$
WA70 (π^+) $p_T \in [4.25, 4.5]$
WA70 (π^+) $p_T \in [4.5, 4.75]$
WA70 (π^+) $p_T \in [4.75, 5.0]$
WA70 (π^+) $p_T \in [5.0, 5.5]$
WA70 (π^+) $p_T \in [5.5, 6.0]$
WA70 (π^+) $p_T \in [6.0, 7.0]$
WA70 (π^-) $p_T \in [4.0, 4.25]$
WA70 (π^-) $p_T \in [4.25, 4.5]$
WA70 (π^-) $p_T \in [4.5, 4.75]$
WA70 (π^-) $p_T \in [4.75, 5.0]$
WA70 (π^-) $p_T \in [5.0, 5.5]$
WA70 (π^-) $p_T \in [5.5, 6.0]$
WA70 (π^-) $p_T \in [6.0, 7.0]$
$\frac{d\sigma}{d\sqrt{\tau}dx_F}$
$E\frac{d^3\sigma}{dp^3}$
x_F

Thank you